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A discussion of automation

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A DISCUSSION OF AUTOMATION

By

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For

Dr. A. Rex Johnson

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PREFACE

The subject, automation, is ubiquitous. Hardly a week passes that one of the popular magazines does not have an article of interest on the subject. Congress has found the subject to be of enough importance to have hearings before the Subcommittee on Economic Stabilization of the Joint Committee on the Economic Report in October, 1955. These hearings brought forth a flood of news items on automation in the daily newspapers; their frequency has just begun to diminish. It is the purpose of this paper to collect the interesting and pertinent facts on automation and to discuss what effect it may have on us as individuals.

PREFACE

The subject, automation, is everything. [illegible] [illegible] [illegible] assert that one of the popular conceptions [illegible] [illegible] [illegible] of interest on the subject. Congress has found it [illegible] of enough importance to have hearings before the Subcommittee on Economic Stabilization of the Joint Committee on the Economic Report in October, 1955. These hearings brought forth a [illegible] [illegible] [illegible] automation in the [illegible] [illegible] [illegible] [illegible] just begin to [illegible]. It is the purpose of this paper to collect the [illegible] [illegible] [illegible] [illegible] and discuss what effect it may have on [illegible].

TABLE OF CONTENTS

INTRODUCTION

THE ORIGIN OF THE WORD AUTOMATION

The recent popularity of feature articles on automation may be due in part to the newness of the word itself. In less than ten years the word has been coined, popularized, given a multitude of meanings, and made a part of our everyday language.

The first person to use the word automation was Delmar S. Harder, executive vice president of Ford Motor Company. His intention was modest--he used the word to describe a new step taken by Ford after World War II--mechanization of the handling of work pieces between machines that perform successive tasks. This innovation was achieved by "transfer" machines.[1]

Another source of the word automation came from the Harvard research group report "Making the Automatic Factory a Reality" by John Diebold, et al.[2] According to him, the author found the word automatization awkward, and from the standpoint of his weak

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[1]Herbert Solow, "'Automation':News Behind the Noise," Fortune, April, 1956, p. 150.

[2]John Diebold, Automation, the Advent of the Automatic Factory, (New York, Toronto and London: D. Van Nostrand Company, Inc., 1952), p. ix.

spelling, hazardous. To be sure, there was also a growing appreciation of the advantage of recognizing the area of automation as distinct from the technology of control. But it is only fair to confess that it was the ease of spelling that finally overcame the author's reticence to coin a new word.[1]

Not only has Mr. Diebold been connected with the coining of the word, but his book on Automation was responsible for introducing and popularizing the word as we know it today.

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[1] *Ibid*.

CHAPTER I

DEFINITION OF THE WORD AUTOMATION

Automation has been defined many different ways by different people. Mr. Diebold gave several significations of the word

> Automation is a new word denoting both automatic operation and the process of making things automatic. In the latter sense it includes several areas of industrial activity such as product and process redesign, the theory of communication and control, and the design of machinery. The connotation intended is delineation of these otherwise loosely related studies as being a distinct area of industrial endeavor, the systematic analysis and study of which will yield fruitful results.[1]

Again Mr. Diebold defined automation as a philosophy of organizing any work as a system in which product, operations research, control engineering, and management science in general constitute the essential approach to details of equipment and process.[2]

Before the Congressional Subcommittee on Economic Stabilization of the Joint Committee on the Economic Report, Mr. Diebold defined automation in another variation:

> Automation is a means of analyzing, organizing, and controlling our production processes to achieve optimum use of all productive resources--mechanical and material and human.
>
> There are two basic steps that industry follows in the approach toward automation. The first of these is the organ-

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[1] *Ibid*

[2] Solow, *op. cit.*

ization of each of the several steps of the production process into a fully integrated system. The oil refineries pioneered in this step; the chemical industry, processing industries, and nuclear production have since followed in going through this first step of automation. They have changed what had formerly been batch processes into integrated systems.

The second step of automation is to take the system and to control it in such a way that it operates at optimum all of the time. I think there has been a great deal of confusion upon this point, and you may very well see this reflected in some of the statements during the course of the hearings. People who are not familiar with the process industries will point to oil refineries and say: "This is automation. Other industries are going to develop in the same way." Actually, by the introduction of control systems into oil refineries and other processing industries--paper manufacturing, sugar refining, chemical manufacture, etc.--a second stage of automation is being achieved. Here it is not a case of replacing hand labor by machines, but rather of operating the machines at optimum efficiency all of the time

I think it is possible to characterize the nature of automation by three simple statements: First, the concept of automation is very simple. It is a welding together, as I have said, of the production steps. It is looking at production processes as closed and integrated systems. Secondly, the technology of automation is incredibly complex. It is easily among the half dozen most advanced technologies of our time. Fundamentally, it deals with the transmission and use of information for the purposes of machine control, and for the purposes of optimizing production. I think you may be interested in the origin of this technology. The indivual use of self-regulating mechanisms--devices that can regulate the course of their own activity--is very old. It goes back to the float-control valves the Romans used, and devices used by the early Dutch to keep windmills facing into the wind. James Watt devised a regulator, the "flyball governor", to keep his steam engine operating at constant speed, and there have been a number of other uses of this concept of self-regulation, which is known as feedback.

During World War II, the theory and use of feedback was studied in great detail by a number of scientists in this country and in England. The introduction of rapidly moving aircraft very quickly made traditional gun-laying techniques of antiaircraft warfare obsolete. It was impossible to follow such rapidly moving targets manually. As a result, a large part of the scientific manpower in this country was directed toward the development of self-regulating devices and systems to control our military equipment. It is out of this work

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that the technology of automation, as we understand it today, has developed. During the last 10 years, this technology has begun to be applied to industry. Yet it is not so much the technology itself, but rather the way it is applied, that is properly called automation.

I think the third point about automation that may help to give an understanding of its nature is that its application is very widespread. Automation can be applied in many types of businesses and industries. If automation is regarded as a philosophy, a way of organizing production, it is something that can be applied in areas where only a small amount of actual mechanization is possible. It seems to me that a good example which will clarify this point is the automation of office procedure. We have developed, through the use of the new technology, the machines you mentioned in your introduction: computing machines and data-processing equipment. Through the use of this equipment it is possible to automate office operations which hitherto have been conducted entirely by hand.

In the factory, automation means basically two things: It means, first of all, the integration of production machine which may in fact be no more than a new level of mechanizatio An often-cited example is the Ford plant in Cleveland, where injection blocks are made quite automatically by the use of a series of special-purpose machines--an automatic mass-production line.

Most of American industry, however, depends upon short runs of product. About 89 to 90 percent of all American production is in lots of less than 25 individual pieces. It is impossible to build special-purpose machines to manufactur these, because the character of the product changes too frequently. This is where the second meaning of factory automation comes in. In such a job-shop operation automation is just beginning to be achieved, in the form of tape-controlled machine tools--machines for which instructions can be provided in a flexible and variable form. This kind of automation is just beginning to have an impact. It gives every impression of taking a very long time to come about.[1]

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[1]U. S. Congress, Subcommittee on Economic Stabilization of the Joint Committee on the Economic Report, Hearings, Automation and Technological Change, 84th Cong. 1st Sess., 1955, (Washington: U. S. Government Printing Office, 1955), pp. 8-9. Cited hereafter as Congressional Subcommittee on Economic Stabilization Hearings, 1955.

Sometimes automation is referred to as the second industrial revolution. The first industrial revolution replaced the energy of men with energy from steam. This replacement of men with machines is called mechanization. Two human functions are theoretically replaceable by machinery. These functions are the provision of energy and the handling of information. Mechanization has generally been known to replace the first. But the governor on James Watt's steam engine in 1788 also provided information-gathering, feed back control mechanism performing the same handling of information which is generally thought of as being associated with automation. On the other hand, the transfer of work materials between machines that perform successive tasks was termed automation by Mr. Harder, who is generally acknowledged to have coined the word nearly eight years ago. Consequently, the difference between mechanization and automation is not clear. The growing use of automation may be attributed to the spectacular development made in this field, and the fleeting and unreal dreams of men of Utopia, where machines perform all work, leaving plenty of opportunity for leisure and pleasure.

The similarity between automation and mechanization is brought out in the article "How to Evaluate Automation" by James R. Bright.[1] He determines the degree of automation by use of a mechanical profile which measures a manufacturing process against

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[1]James R. Bright, "How to Evaluate Automation," Harvard Business Review, July-August, 1955, pp. 101-111.

17 levels of mechanization. These levels are:

1. Hand
2. Hand tool
3. Powered hand tool
4. Power tool, hand control
5. Power tool, fixed cycle (single function)
6. Power tool, program control (sequential functioning)
7. Power tool, remote control
8. Actuation by introduction of work piece or material
9. Measurement of a characteristic
10. Signalling the measurement value
11. Recording performance
12. Changing speed, position or direction according to measurement.
13. Segregating or rejecting according to measurement
14. Identifying and selecting appropriate action
15. Correcting performance after operating
16. Correcting performance while operating
17. Anticipating required performance and adjusting accordingly.

Examining the levels of mechanization, automatic control begins somewhere between 9 and 12. Consequently, some disciples of automation claim that these are the levels that mark the division of automation from mechanization. However, Mr. Bright does not agree. He concludes that automation is the act of doing things more automatically.[1]

Mr. Bright does think that all seventeen levels of mechanization should necessarily be performed due to the expense of replacing human labor with higher priced machine work. He proposes the mechanical profile as a basis for further study for feasibility before commencing a replacement program.

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[1]Ibid, p. 109.

Another definition of automation is given by an economist Walter S. Buckingham., Jr., Associate Professor, Georgia Institute of Technology:

> The variety of popular uses of the term "automation" necessitates some definition which is both precise and relevant for analysis. Such a definition can best be derived from an examination of the major principles which underlie most if not all of the popular concepts of automation. These are four such major principles--mechanization, feedback, continuous process, and rationalization.
>
> Mechanization means the use of machines to perform work. Sometimes mechanization substitutes machinery for human or animal muscle. The steam engine did this. Sometimes mechanization substitutes machinery for brainwork at the lower, routine levels. The electronic computer does this. Because of the power compactness or speed of machine operation, mechanization usually permits tasks to be performed which could never be done by human labor alone, no matter how much labor was used or how well the enterprise was organized and managed. Mechanization increases wealth and reduces drudgery in the long run, but in the short run it may cause hardships to workers whose skills are rendered obsolete, diluted by a further specialization or whose jobs are abolished altogether.
>
> Feedback is the second principle inherent in automation. This is a concept of control whereby the input of machines is regulated by the machine's own output so that the output meets the conditions of a predetermined objective. As in a simple, thermostatically controlled heating system, the conditions created by the output automatically control, in turn, the amount of input and hence the performance of the machine. When controlled by the feedback principle, machines start and stop themselves and regulate quality and quantity of output automatically.
>
> Continuous flow or process is the third principle of automation. This concept is of increasing importance because it is spreading from many individual production processes to the business enterprise itself and on to the entire economy. Mass production, increasing interdependence and now automation all embody this principle which is leading to a concept of the business enterprise as an endless process. Business for the most part has ceased being an operation that can be started and stopped with small loss. The regulation of a constant flow of goods has become a major concern of management.
>
> This continuous-process idea has changed the function of management. The man of daring and imagination who relied on hunch supported by experience has become a technological

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casualty. The shrewd bargain has given way to the carefully calculated risk. The increasing size and complexity of business enterprises precludes the top executives from having knowledge of the details of the firms' operations.

Decisions must be made by groups who rely on reports from the sales, production, accounting and other departments. Top executives today are forced to view their functions as consisting of planning, controlling and coordinating the firm's operations and harmonizing the interests of the firm with those of employees, investors, suppliers, and customers. Because of the high degree of interdependence in the economy the decisions of these executives intimately affect the lives of millions of people.

Rationalization, the fourth principle of automation, means the application of reason to the solution of problems or to the search for knowledge.

In a production system it means that the entire process from the raw material to the final product is carefully analyzed so that every operation can be designed to contribute in the most efficient way to the achievement of clearly enunciated goals of the enterprise.

Actually, rationalistic philosophy is nothing new, having become an important force in the world with the Renaissance. However, the scientific, rationalist philosophy takes on numerous new implications when it can be implemented by modern electronic machinery. The rise of electronic computers has led to a fascination with the possibility that superrationalism in the business and scientific spheres might spill over and transform society into an exact mechanism in which all elements of chance, risk, capriciousness and free will, as well as all spiritual values, would be eliminated. Although this kind of speculation is highly dubious, nevertheless it is one logical extension of this fourth principle of automation.

Following these four principles--mechanization, feedback, continuous process and rationalization--automation can be given a definition precise enough to be useful for logical analysis. It can be said to be any continuous and integrated operation of a rationalized production system which uses electronic or other equipment to regulate and coordinate the quality and quantity of production.[1]

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[1]Congressional Subcommittee on Economic Stabilization, Hearings, 1955, pp. 31-32.

There are many more definitions of automation. Mr. W. W. Barton, President of W. F. and John Barnes Company of Rockford, Illinois, defines automation as an innovation created by man to increase his production: technocracy, if you will.[1] Mr. Barton's firm designed and built the Rockford Ordnance Plant, which has been pointed out as an automatic factory by some writers.

Mr. Robert Bendiner writes that automation, in the broadest sense, means the operation of a productive system without human operators, or hardly any.[2] He then expands this definition by saying:

> For automation at its fullest is not merely the existence of separate machines, however automatic, but the controlled operation of an entire factory or process in which the machines, as linked units, automatically perform their manipulations in specified sequence, with electronic judgement substituted for the perception of the machinist or the foreman.[3]

The Committee on Economic Policy of the Congress of Industrial Organizations (CIO) names the following three developments as formulated by Professor George B. Baldwin and George P. Schultz of the Massachusetts Institute of Technology as embracing nearly everything that can be brought under the term "automation":

> 1. The linking together of conventionally separate manufacturing operations into lines of continuous production through which the product moves "untouched by human hands". This first development, which depends primarily on mechanical engineering for its adoption, we shall refer to simply as "integration", a term already in wide use in the metal working industries. It is also called "Detroit Automation" in honor of the industry in which it got its start. "Continuous automatic production" is another and perhaps more descriptive term being used.

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[1] Ibid, p. 246.

[2] Robert Bendiner, "The Age of the Thinking Robot and What It Will Mean to Us," The Reporter, April 7, 1955, p. 1.

[3] Ibid, p. 2.

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2. The use of "feedback"control devices or servomechanisms which allow individual operations to be performed without any necessity for human control. With feedback, there is always some built-in automatic device for comparing the way in which work is actually being done with the way in which it is supposed to be done and for then making, automatically, any adjustments in the work-process that may be necessary. . . It is dependent primarily not on mechanical but on electrical engineering knowledge and techniques.

3. The development of general and special purpose computing machines capable of recording and storing information (usually in the form of numbers) and of performing both simple and complex mathematical operations on such in formation.[1]

One conflict found in the many different definitions is the dating of the beginning of automation. Some authors like to believe it began with mankind, others feel it to be a postwar development in technology, others feel that it is a level of mechanization. Another difference is defining what characterizes automation in production. A third difference is the object of automation--whether it is optimum production or economic production or a combination of the two. However, if these differences are considered to be minor, then the various definitions presented will not be confusing.

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[1]Congress of Industrial Organizations, Automation, a Pamphlet Prepared by the Committee on Economic Policy, (Washington: Congress of Industrial Organization, undated), pp. 3-4.

2. The use of [illegible] machines [illegible] and [illegible].

3. The development of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] mathematical [illegible] [illegible] [illegible].[1]

The analysis found in the most pertinent [illegible] [illegible] the custom of the legislation of valuation. [illegible] [illegible] [illegible] it began with [illegible] [illegible] [illegible] [illegible] [illegible] equipment in [illegible], [illegible] that [illegible] [illegible] [illegible] [illegible] ization. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] mation in production. [illegible] [illegible] [illegible] [illegible] the [illegible] of [illegible] tion—whether it is [illegible] [illegible] [illegible] [illegible] combination of the two. However, it [illegible] [illegible] [illegible] [illegible] [illegible], that the various definitions presented [illegible] be confusing.

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[1]Conference of Industrial [illegible], [illegible] [illegible] [illegible] by the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of Industrial Organization, [illegible], pp. [illegible]

CHAPTER II

HISTORICAL BACKGROUND OF AUTOMATION

If automation is any innovation created by man to increase his production, then the idea of automation is admittedly as old as man himself. Neanderthal man used a club and employed jagged pieces of flint to perform operations better than they could have been performed with bare hands.[1] In Biblical times the David and Goliath story illustrates the use of a sling shot to substitute for the throwing action of the arm. History has recorded the use by the Romans of a hydraulic float valve to control automatically the level of the water in storage tanks. In this case they used a sensing device to control an operation. The Dutch used vanes on their windmills to keep the rotating blades in the direction of the wind.

The perfection of the steam engine in 1769 by James Watt was the breakthrough in substituting mechanical energy for human or animal energy. Watt, in putting his steam engine to work, invented the flyball speed governor, which was a sensing device, controlling the speed of his steam engine, without use of human effort.

In this country in 1784 Oliver Evans had in production outside of Philadelphia an automatic flour milling plant which was powered by water. No human labor was required from the time the

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[1] Congressional Subcommittee on Economic Stabilization, Hearings, 1955, p. 398.

grain was received at the mill until it had been processed into finished flour. The French in 1801 made another contribution to the development of automation when Joseph Marie Jacquard, a weaver, exhibited an automatic loom controlled by punch cards, similar in many ways to the punch cards used in modern office equipment. Mr. Allen V. Astin, Director of the National Bureau of Standards, in a talk given to the Armed Forces Communications Electronics Association in Washington in February, 1956, discussed this contribution of Jacquard as follows:

> It was he who devised the principle of storing control information on a punched card. How he arrived at this principle is one of the curiosities of the science of automation. Jacquard wanted a means for reproducing certain patterns on tapestries. He hit upon the idea of punching control information on cards. The holes on these cards would, in turn, control the action of rods which guided the threads of his loom. The holes on his card, therefore, served as a storage and record unit of his patterns and also as the control for his weaving machine. It is true that he needed thousands of cards to weave a single tapestry, but again the principle is there. Jacquard had devised a method for storing man's commands for later use in machines.[1]

On this side of the ocean a contemporary of Jacquard was making a contribution to the mass production technique. Although Eli Whitney's invention of the cotton gin is well known, his other contributions may have been overlooked. In the days of handcraft, parts comprising a mechanism were made on an individual basis and then fitted to work together. Eli Whitney, by improving the science of measurement, was able to make parts on an individual

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[1]Allen V. Astin, "A Brief Look at the History of Automation", A Talk Given to the Armed Forces Communication Electronics Association, (Washington, D. C., February 2, 1956), mimeographed, p. 4.

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basis which, because of their similarity, could be interchanged. He used this technique in the manufacture of firearms, and its success made him a fortune.

The English contemporary is Charles Babbage, the father of the modern computer. Although he was able to construct only a workable digital computer, his drawings, design and writings were the basis for an analogue computer. In 1930 Vannevar Bush and his associates at the Massachusetts Institute of Technology succeeded in producing a workable differential analyzer (analogue machine) which was electro-mechanical. An analogue computer solves problems by creating physical quantities (mechanical, or more recently electrical) in analogy to the problem to be solved. In other words, a model using mechanical and/or electrical quantities is set up to duplicate the problem to be solved. In 1945 Mark I (Automatic Sequence-Controlled Calculator) was completed at the Harvard Computation Laboratory. This was the first high speed digital computer. The electronic developments during World War II paved the way for construction of electrical, rather than the much slower mechanical computers. Since 1945 a new family of these high speed computers, both analytical and digital, has come into being.

The latest computers have extraordinary speed, large capacity, and many are designed to be fitted into some working process as a control device. In his talk given to the Armed Forces Communications Electronics Association[1], Mr. Astin discussed the modern

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[1]*Ibid*, p. 8.

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computer as a control device as follows:

> With modern computers, man has at last created an instrument through which he can delegate certain limited powers of judgment and decision. Of course I do not mean that the computer is capable of thinking per se. What I do mean is that man has now devised a scheme by which he can effectively store the criteria for certain decisions and thereby specify the electronic paths and electronic alternatives which the machine must take based upon data resulting from examination and comparison. And all this can be done at high speeds. This, I think, offers the greatest promise for automation. This is what characterizes automation as a most unique part of mechanization and what makes automation a comparatively young part of our history.[1]

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[1] *Ibid*, p. 8.

CHAPTER III

AUTOMATION IN INDUSTRY

Detroit automation ranks in popularity with high speed computers as a subject for newspaper and magazine articles. It is fundamentally a new method for handling products between various steps in mass-production assembly line. This automation was linked with the automobile industry centered around Detroit. It has spread to large areas of the metal-working, electrical, electronic, meat packing and food process industries because it is usually profitable in those areas wherever repetitive operations are to be performed on long production runs of identical parts. Mr. Diebold said:

> Not long ago, for example, an automobile engine block was milled at one machine, removed by a worker and put on a conveyer, again removed by another worker and bored at the next machine, and so on as the engine moved spasmodically down the line. Today complex handling devices, often as large as the production machines themselves, automatically remove the parts from the milling machine, turn and position them as necessary and hold them in place for the next machine's operation. Thus, an engine block goes from a rough casting to finished product--which may involve as many as 530 distinct operations--in a continuous, automatic journey. One such line, at the Ford Motor Company's Cleveland plant, performs the entire process in less than 15 minutes.[1]

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[1]John Diebold, "What is Automation?", Colliers, March 16, 1956, p. 39.

The Committee on Economic Policy of the Congress of Industrial Organizations stated that:

> The machining department of the Ford engine plant in Cleveland is, perhaps, the best-known example of what is called 'Detroit Automation'. In this plant, which has been in operation for three years, engine blocks are machined by a linked battery of machines on a line some 1500 feet long. Automatic machine tools perform more than 500 boring, broaching, drilling, honing, milling, and tapping operations, with little human assistance. The timing of each operation is synchronized so that the line moves forward uniformly.[1]

On the same subject, Mr. Solow states:

> As a result, of course, fewer man-hours of direct production work are required. But there must be more maintenance labor. Moreover, photographs that show the great new machines unattended or with only one attendant are misleading. There are still inspectors and operators on all the lines. A so-called tool-control board does not really control tools; it merely signals an operator when a timing device indicates that a tool is reaching the end of its usefulness. Then the operator replaces the tool. Not even in the brand-new Plymouth engine plant is assembly completely automatic. Machine assembly stations are interspersed with manual stations. After assembly, a transfer machine puts engines into test beds, and test attachments (for fuel, water, etc.) are connected automatically. The engine is then tested automatically, but when a light signals a defect, an operator must intervene.[2]

And again the Congress of Industrial Organizations states:

> It has been estimated that 154 engine blocks run through the production line in an hour, at the Ford plant in Cleveland, requiring 41 workers on the line. The same production pace, under older methods, requires 117 men.[3]

For the views of the Ford Motor Company on the initial installation of Detroit type automation, the following discussion is quoted from the Hearings before the Subcommittee on Economic

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[1] Congress of Industrial Organizations, op. cit., p. 4.

[2] Solow, op. cit., p. 153.

[3] Congress of Industrial Organizations, op. cit., p. 12.

Stabilization at the Eighty-Fourth Congress. The discussion is between Mr. D. J. Davis, Vice-President, Manufacturing, Ford Motor Company, and Mr. William H. Moore, Staff Economist of the Subcommittee:

Mr. Davis. I would say automation such as we started in 1952 when our engine programs went into full swing in new plants at Cleveland, at that time automation cost approximately 25 per cent more than if you bought the normal machine tools.

Since then we have standardized a good many elements used in automation, and the cost is somewhat less, but as I said in my statement, there are very few parts that you can really do a bangup job of automating on. I might tell you this: That in our Cleveland and Dearborn engine plants we have automated lines on cylinder blocks, cylinder heads, connecting rods, chankshafts, and camshafts. That is all for the engine. Totally, in the company, perhaps only 6 percent of our employees, direct labor employees, work on automated lines.

Mr. Moore. What percent?

Mr. Davis. 6 percent.

Mr. Moore. How many employees does the company have?

Mr. Davis. About 146,000 hourly employees.

Mr. Moore. So you mean there would be some 10,000 of those?

Mr. Davis. That's right. Mr. Donovan advises me that would be on the high side.

Mr. Moore. You have referred to the combination of standard elements into transfer and automatic machines.

I suppose as a converse to that you would say 75 percent on one of these automated lines are standard milling machines that might once have been operated by a human operator.

Mr. Davis. That is not quite right, sir. I say that the automation costs an additional 25 percent.

It is true that these in-line or transfer machines in themselves are automated between stations, and the automation I speak of is that which goes in between these machines.

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For example, a cylinder-block line consists of 71 machines hooked together automatically. That single machine, as you look at it now, is perhaps 1600 feet long, but it has 71 pieces of automation in between these machines. To move the part automatically between the various in-line operations, it is that long.

Mr. Moore. Of the total capital cost of that machine, you would say 25 percent was sunk in automation.

Mr. Davis. I would like to clarify it for you by saying this, that a cylinder-block line producing 140 units an hour at 80 percent efficiency--bear in mind, when I say "80 percent efficiency", it is only possible to operate at 80 percent efficiency through use of automation. If you had no automation, you would be lucky to get 65 percent efficiency in that line, but the pieces of equipment that lay in between these pieces of end-line machinery are the 25 percent in extra dollars that I speak of.

I say that a cylinder-block line not automated would cost $7 million. Our first attempt at automation cost us 25 per cent more than that.

Mr. Moore. When you automate a line or reach the decision to do so, is it practical to convert an existing plant or do you move from, say, Dearborn to Cleveland and then again from Cleveland to Dearborn the next time?

Do you allow an old plant to sort of wither on the vine and abandon it and go out and start fresh building a new automated plant?

Mr. Davis. That is what we would like to do. We are not always able to do that because of the expenditures.

You recall, the first line I said we automated was at Cleveland. When we put that automation in at Cleveland, there was nobody in the business that was selling any equipment in that line. We had to go out from--start from scratch and do a good deal of the designing ourselves.

Mr. Moore. Had you been making engines in Cleveland at that time?

Mr. Davis. No. We had to interest people on the outside to go into building of automation equipment, people like the Wilson Company of Detroit. We learned after we made that installation that we had very little flexibility, so we set a group to work trying to standardize on these automation units.

We now have standard 3-foot units, 6-foot units, 9-foot units, that would either turn the work over, rotate it, or do

something to position the part.

> As a result of that standardization program we have much more flexibility and we can take, for example, a piece of equipment off the cylinder-block line and use it on the cylinder head line.[1]

In the oil industry and many chemical industries employing gaseous or liquid materials, automation has been developed to a very high degree.

> True automatic control in chemical production and oil refining awaits improved knowledge of processes and the development of on-stream analytical instruments, of which there are still very few. Already, however, the continuous process industries are fairly sophisticated. To their engineers "automation" means, if not automatic control, at least automatic monitoring and logging of data as a basis for improved manual control and better product yields. The control panel and system were designed and built by Panellit, Inc., of Skokie, Illinois. Lines between individual pictures indicate directions of information flow. The panel centralizes instrument read-offs and manual controls. Instruments are monitored and readings are logged automatically. When tolerance limits are exceeded, the typewriter shifts to red ink. The operator, relieved of panel monitoring and manual recording, watches the typewriter and can quickly adjust controls. A data-reduction device automatically calculates relationships among temperatures, pressures, and flow rates, thus making it possible for the operator to adjust tolerance limits as well, a job that formerly waited on much slower computations by the technical department. In time, the panel may largely disappear, but the operator will long remain.[2]

Mr. Otto Pragan, Research Director, International Chemical Workers' Union, discussed the status of automation in the chemical industry in general as follows:

> Production in the chemical industry lends itself readily to the use of automatic devices. As a rule, the production process is a continuous one, operating 7 days a week and 24

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[1]Congressional Subcommittee on Economic Stabilization, Hearings, 1955, pp. 61-62.

[2]Solow, op. cit., p. 154.

hours a day. It is mass production--not through an assembly line--but by means of a continuous, automatic process. Often, manufacturing is performed in large chemical reactors, fractionating towers and other installations which are largely regulated by automatic control devices.

Continuous processing methods with the aid of controlling devices make it possible in a single operation to combine or to separate several different chemicals in order to derive one or more end products, as the case may be. This frequently permits production of large quantities of chemicals with only a handful of production workers. For instance, a recently built plant in the compressed gas industry employs only two production workers. In addition, operations in some branches of the chemical industry that are concerned with testing, filling, inspecting and packaging, after the product has come from the production line, also use automatic equipment. This is particularly the case in the soap, drug and pharmaceutical industries.

Ability to produce chemicals in large volume reduces unit costs considerably since the number of production workers need not vary directly with changes in the volume of production as in the case of many other industries. Therefore, output can be substantially increased without any increase in the number of production workers.

Among production workers in the industry, chemical operators are the largest occupational group. Their jobs include working with equipment which controls temperature, pressure, flow and levels of liquids and gases, and reaction time. Other operator classifications include stillmen, who operate distillation equipment; driers, whose function is to separate waters from solids; batch makers, who operate mixing machines; and millers, who operate pulverizing equipment.

The predominance of automatic equipment and other complex machinery in the industry makes maintenance skills, such as machinists, pipefitters, electricians, instrument men, etc., particularly important. For this reason, the ratio of maintenance workers to production workers is greater in the chemical industry than in most other industries. Although detailed data are not available, some plants employ as many as 1 maintenance employee for every 2 production workers.[1]

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[1]Congressional Subcommittee on Economic Stabilization, Hearings, 1955, p. 167.

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The electronic data-processing system is doing for office work what "Detroit" automation is doing for production. The management firm of Haskins and Sells describes the system as follows:

> In this system, many of the basic functions in record keeping are handled at electronic speed. The preparation of source documents is performed generally by the same means as those employed in the punched-card system. Both this step and the transfer of data from the source documents to a medium acceptable for electronic processing are accomplished by input preparation equipment. This equipment transcribes source data onto tapes or cards by the direct punch or mark-sensing method, aided by an intervening mechanism which converts the data into a binary code, the language of the electronic system. The medium may be magnetic tape, paper tape, or punched cards. Magnetic tape is by far the fastest--it can be read into the central processing unit of the system at speeds as high as 56,000 characters a second whereas the maximum for paper tape is about 1000, and for punched cards around 325 characters a second.
>
> In the manipulation function of record keeping all the assembly, sorting, classification, reference, and arithmetic operations are performed automatically within the components of the system, directed by a series of stored instructions, called a program. It is mainly the performance of the manipulations function that sets apart the electronic system as unique and it is there that the electronic system gains its greatest advantage over others. Storage capacities of the system make possible the retention of data from master files, carry-forward balances, intermediate results, and the like, thus obviating the need for temporary filing, separate cross references, and other manual handling. Access to stored information, intercommunication within the system, computation, and the making of decisions--all required in the manipulation function--occur at electronic speed.
>
> Results from electronic data processing are withdrawn from the central processing unit, written upon magnetic tape, paper tape, or punched cards, and fed into automatic printers. Alternatively, output data may be produced by direct connection between the processing unit and the printing device, eliminating tapes or cards.
>
> Beyond the preparation of the program and input data, human participation plays only a minor part in supervisory control in the electronics system. Substantially all required supervision is provided for in the program.
>
> In addition to the handling of the conventional record-keeping functions, electronic equipment has a far greater potential in alternative uses than is found in other systems. Possessed of the immense advantages of superior capacities and

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speeds, electronic equipment brings within reach of attainment a higher level of effectiveness in production control, sales analysis and forecasting, inventory control, and other tasks of business management. Superior capacities and speeds not only permit the present job to be done faster; they also make possible the accomplishment of tasks never heretofore attempted because of the impracticability, under other systems, of completing them in time for the results to be effectively utilized.[1]

In an article on office automation prepared for publication in Dun's Review and Modern Industry, a typical example of the electronic data-processing system is described:

A typical example is the installation at the Rockwell Manufacturing Company which makes it possible for Rockwell to process an order in one day, rather than the week or more it required under conventional procedures. Although Rockwell has two divisions, its venture into near-automation was limited this year to one system, order processing, in one division, Delta Power Tool.

Under its former system, there were three geographical areas where sales orders were written. Multipart order invoices were typed manually at each location and processed there through shipping and billing.

Their new system uses combinations of coded, five channel, punched paper tape, key punches, prepunched cards, teletypewriters, card-to-tape machines and leased communications wires. In order to utilize this gear most efficiently, all order writing is centralized in the main Pittsburgh plant. There are seventeen basic forms in this operation. All but four are now automatically processed.

The important competitive weapon for management in this is the spate of accurate and detailed reports on shipments and new orders now coming through daily. And, a fact that every sales VP will appreciate, the higher degree of accuracy possible through punched-cards and tape means that the customer gets what he ordered and is billed for it correctly.

In another manufacturing company, nameless here, faulty preparation of order documents had reached a point where the wrong stock was being pulled from inventory on over 30 percent

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[1]Haskins & Sells, Data Processing by Electronics, (A Basic Guide for the Understanding and Use of a New Technique), (May, 1955), pp. 11-12.

of the orders. After "debugging" their new almost-automated order system, the rate of error dropped to less than one per cent.

At Rockwell the error rate was about two-tenths of one per cent.

A cost estimate for a system of this type might be in the neighborhood of $60,000, including pro-rated purchases, rentals, forms and manpower. Savings could reach as high as $70,000.

The cautious approach with limited objectives followed by Rockwell seems to set the pattern for the bulk of industry. Republic Steel Corporation, for instance, has set up a committee reporting at the vice presidential level whose job it is to study every possible application of integrated data processing at all levels, from regional sales offices to the mills. Their planning is still fluid, but after a year and a half of study of tape and punched card equipment, they have ordered an intermediate-size computer for one of their plants. Depending upon their experience with this, they may orient their data processing so that all basic handling is done, decentralized, at the mill level or they may eventually centralize most data handling in Cleveland. Says their committee chairman, "It depends on how we progress..."[1]

The cautious approach by most companies to integrated process data is understood when trying to relate the equipment, which is already ahead of management's comprehension of what it will do, to a system of data processing that has been built up using a different principle of collecting data by small units, passing only the summarization to the next higher unit where the process is repeated until the information reaches top management. So far there has been no proved one best method of adapting the equipment to the system. The biggest problem facing the industry is to determine standards so that the equipment and the present methods can be oriented to the same standard. Another determining factor is the high price of the equipment and rapid progress being

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[1]James K. Blake (ed.), "The Fitful Beginnings of Office Automation", Dun's Review and Modern Industry, October, 1955, pp. 59-60.

made in perfecting better machines to fit industry's problems. Many companies are taking a waiting attitude, rather than buying the present equipment and finding it outmoded in the near future.

There have been two approaches to the collection of data by wire from the scattered activities. One approach is to install sub-collection points at strategic locations all over the United States. These centers would summarize and transmit at a faster rate, using magnetic tape to the main center. The other system is to send all data directly to the main center.

At the main center the data would be processed. The alternate object is to create an even flow of raw data, which, as it is poured through "converters" will be transformed into finished products automatically -- invoices, bills of lading, daily sales analysis, while storing information to grind out monthly and semi-annual reviews -- in other words, automation. The gleam in the eyes of research staffs of the office equipment manufacturers reflects a long time ideal, the day when data will be recorded manually only once.

One of the most worrisome problems facing the military in the United States is a defense against the inter-continental bomber. Two developments have brought about this apprehension. The first is the tremendous destruction wrought by an atom or H bomb. One plane carrying one of these bombs can do the work of fleets of airplanes carrying conventional bombs. The second development is the supersonic bomber. The high speed of the airplane makes interception difficult because of lack of time. The problem of interception and destroying enemy bombers has been tackled in two ways.

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First, the range of detection has been increased by the use of better radars, and the positionizing of the radars closer to the enemy. Radar picket ships, Texas towers, and the radar guard lines in Canada are used to increase the time of detection. The second way of meeting this problem is being solved by the Lincoln project, otherwise known as SAGE (semi-automatic ground environment machine). All the information received from the outlying radar stations on land, sea and in the air, or from the Ground Observer Corps, is fed into a complex electronic brain. An interesting editorial entitled "Automation in War" appeared in The Evening Star on January 23, 1956. The following is quoted from it:

> SAGE is a complex electronic "brain" capable, its creators assert, not only of supplying instantly accurate details as to the strength, nature, direction, speed and altitude of an approaching enemy air fleet, but of organizing and directing our counterattack. The "brain" can immediately distinguish friend from foe--a problem that proved extremely difficult in World War II. Its warning as to numbers and tactics of an invading air squadron is transmitted to a human controller (hence the "semiautomatic" part of its name). It also transmits to him a complete picture of all our interceptor planes and missiles available in the threatened area. By pushing a button, the human director then can put in motion a concentrated interception strike, with the automation device actually steering the piloted planes and unpiloted missiles to the correct point of interception. Pilots of the planes "just go along for the ride", but are available to act in case of an electronic failure. Also they may launch the air-to-air missiles against enemy aircraft if they choose. Otherwise SAGE will do the firing for them.
>
> This, then, is the amazing result of five years of intensive research and development under the so-called Lincoln Project, a billion-dollar joint enterprise of the Massachusetts Institute of Technology, other colleges, private industry and the Defense Department. Production of the components of the system already has begun on an expedited basis. When the new defense machinery is operating, the Nation's security against attacks by air will be raised to a 90 per cent level, according to those who have developed the system. That is, they say, it should be possible to knock down 90 per cent of invading aircraft -- as compared with the 30 per cent hoped for with exist-

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> ing facilities. Even if the estimates of SAGE's efficiency should prove to be a bit exaggerated, it appears that a highly significant defense step has been taken.[1]

The heart of SAGE are the electronic computers manufactured by International Business Machines. These computers are able to extract the required information from the electronic sensory boxes and integrate this information with the incoming detection reports, and transmitting the answers to a control center where skilled controllers monitor the action. It does this in matters of seconds, whereby under the old system skilled teams required minute to get the required information. Akin to this speed of solution is SAGE's ability to handle a tremendous amount of information. Under the old system, heavy raids would overload the system.

James J. Haggerty, Jr. brings out more details of the operation of SAGE in his article "The Electronic Paul Revere" in Collier's magazine dated February 3, 1956, pages 82-85.

A by-product of SAGE is its adaptation to solving commercial aviation perils. Charles Yarbrough wrote an article on this subject which appeared in the Washington Sunday Star on Feb. 5, 1956. He said:

> Applied to civil air traffic, it could possibly remove the inevitable lag in aviation communications between control tower and plane, space aircraft to avoid mid-air collisions and eliminate the danger and congestion of bad weather flying.
>
> Three of the units have been ordered after the Government decided to proceed with production before final evaluation because of the "critical situation" in continental defense.

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[1]"Automation in War", Editorial, The Evening Star (Washington, D. C., January 23, 1956), p. 6.

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Dr. Valley told the conference at the Sheraton Park Hotel that he believes the system could be used by civil aviation to help sort out and properly distribute the complex and teeming aircraft picture on civil air lanes.

"And", he added, "I believe it will be used."

Later, it was learned that the Air Co-ordinating Committee, the Air Navigation Defense Board and the CAA have already set up a five-man board to virtually "live with" SAGE.

They will study its application to air traffic and prepare an operating plan for evaluation from a traffic control standpoint.[1]

Another application of automation for defense along the lines of Detroit automation is the Rockford Ordnance Plant. This plant, completed at the end of World War II, manufactures 155-millimeter high explosive shells. This plant operates with a minimum of personnel, and at many of the control stations women control the process through push-button operations. For a complete description of this plant see Hearings, Automation and Technological Change, pp. 253-262. Plants like this could be built in peacetime to manufacture war materials needed in volume during war, such as ammunition. These plants could then be put into reserve, ready to be put on the line in an emergency. This would save many months in converting from peacetime to wartime production.

Automation in the handling of materials in the atomic piles is well known to all of us. This is a case of using automation for safety, rather than for economic reasons.

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[1]Charles Yarbrough, "Automation Seen as Cure for Civil Aviation Perils," The Sunday Star, (Washington, D. C., Feb.5, 1956), pp. A1, A6.

CHAPTER IV

THE IMPACT OF AUTOMATION ON LABOR AND BUSINESS

Generally speaking, unions have not hindered the adoption of automation. They are, however, concerned about the handling of the labor problem. For instance, Dave Beck, President of International Brotherhood of Teamsters, Chauffeurs, Warehousemen and Helpers of America, A. F. L. writes:

> Automation can create higher living standards and more leisure through a shorter work week. It can be a boon to workers.
>
> But it can do these things only if its benefits are distributed wisely and justly; if labor shares adequately in its benefits.
>
> By insisting on the right to bargain on wage and other problems growing out of automation, unions are not trying to impede progress. On the contrary, workers assured of protection and safeguards won by their union will accept changes more readily.
>
> What labor wants is a planned transition, with shock absorbers to soften the bumps on the way to an abundant life for all America. Labor insists that proper steps be taken by industry and, if necessary, by government to protect wage earners.
>
> Labor is for progress. It will not stand in the way of automation, but it will insist on sharing in the benefits brought about by the thinking machines of tomorrow.[1]

C. I. O. President Walter P. Reuther expressed the same hope and concern when he told the Congressional Joint Committee on the Economic Report on February 10, 1955:

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[1]Abraham Weiss, "What Automation Means to You," Pamphlet prepared by the International Brotherhood of Teamsters, Chauffeurs, Warehousemen, and Helpers of America, A. F. L., November, 1955, p. 11.

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THE IMPACT OF [illegible]

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> Automation holds out the promise of vast improvements in living conditions, leisure and national strength. It likewise promises the elimination of routine, repetitive jobs. But the widespread introduction of automation within the coming decade or two will present us with serious economic and social problems, involving dislocations of the labor force, geographical shifts of industry, labor displacement, the upgrading of labor, and the need for substantial yearly increases in consumer purchasing power for rapidly growing markets.[1]

Business men on the whole are apprehensive about labor problems in connection with the displacement of workers by automation. Fortunately, the mass lay-off problem in most cases has appeared only in large companies, because of their greater use of automation. These companies, because of their size, have generally been able to retrain the displaced worker to meet the new skills as controllers of automatic equipment, or because of expansion, have been able to absorb them in other parts of their operation. This successful transition in most cases has not been left to chance, but has been the result of a carefully worked out plan.

> So far, automation has been marked by no mass layoffs, and indeed the temperate attitude of leading users of advanced equipment has given the industrialists at least a debater's advantage. They point out that while fifty thousand telephone operators have been replaced by the dial system, net employment in the industry has steadily gone up; that General Motors has about doubled its employment since 1940 in spite of increasing use of automatic machinery.[2]

Another reason for a successful transition to the use of automation lies in general prosperity and high employment.

> What happened last year was evidence of prosperity--over-employment and not under-employment. At about 3½% of the labor force, unemployment is generally agreed to be close to minimum

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[1]Congress of Industrial Organizations, op. cit., p. 10.

[2]Robert Bendiner, op. cit., p. 5.

frictional levels. In many areas it is getting more and more difficult to find workers with certain skills. One of the blind spots of the unemployment data is the lack of information on how many job openings there are, since unfilled job opportunities are not counted.[1]

So far, the largest users of Detroit automation have been the large companies which mass produce large numbers of a standard product. However, there are many problems to be met and decisions made before automation can be used. Mr. Davis, Vice-President of Manufacturing of the Ford Motor Company, has outlined their experience along these lines:

> The economics of this kind of technological advance are clear. Back in 1908, for example, it took a skilled sheet-metal man, working with handtools, approximately 8 hours to shape the upper half of a fuel tank. Today, in our modern stamping operations, it takes approximately 20 seconds. If handtools were still used to make the upper half of a fuel tank, the labor cost would be approximately $15. Its actual labor cost today is only a few cents. On that same basis, an $1800 car today would cost approximately $15,000.
>
> In today's competitive market we use automation or improved processes, wherever they are justified, in order to reduce costs or improve our product. If we did not use them, we would soon find ourselves at a competitive disadvantage.
>
> Automation, however, cannot be engineered into every job indiscriminately, since it is not always feasible or profitable. Each application of automation must be carefully analyzed before it can be justified. If either daily volume of the part is low or long-term use of the machine is limited, any possible direct labor savings through automation are reduced and may be offset by increased maintenance costs and depreciation or obsolescence. For example, we can economically justify the application of automation to the manufacture of engine components for the Ford engine. The same extensive application of automation, however, cannot be justified on the tractor and Lincoln engine components, due to their lower volume requirements.

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[1] "Automation and the Labor Force," Business and Economic Conditions, First National City Bank Monthly Letter, (New York: February, 1956), p. 23.

As we now see it, there also is little prospect for extensive application of automation in our car-assembly operations, where we assemble in 20 different locations and are faced with technical problems and early changes in product design. Any automation that is applied there must be readily adapted to these changing conditions and alterations at a reasonable cost.

In planning for automation, we must be sure that new machines and equipment will produce acceptable parts without excessive down time and maintenance work. In a standard or nonautomated production line, operators constantly tend and can adjust each machine. If one machine breaks down, a backlog of materials for the machine can be built up while the repairs are being made, to be worked on later on an accelerated schedule.

If one machine in an automated line breaks down, however, all production on that line is halted until the necessary repairs are made. Once the unit is repaired, recovery of lost production must be accomplished on overtime or extra hours.

Although automated machinery and equipment may appear to be technically feasible with respect to a particular part, Ford cannot install them unless they can be adapted, modified, or realined without excessive cost to accommodate the expected changes in the part. Planning for this flexibility requires expenditures of considerable time and money, and when compared with the savings obtainable from automation, we may decide to continue using nonautomated equipment, or to use a reduced amount of automated equipment on these jobs.

If we determine that automated equipment should produce savings in operational costs and that its probable life will permit full depreciation, we must still determine whether its original cost is justified.

Automated machinery and equipment, because of its complexit often cost more (including engineering planning) than nonautomated machines and, in any event, is a new investment. Therefore, increased depreciation charges may nullify savings otherwise obtainable and make the risk of installing new automated production line too great.

On the other hand, particularly where new facilities are necessary, automated equipment may cost less than old-style machines because of savings in materials from combining several operations in one machine, and indirectly, where plant expansion is involved, because of reductions in floor space, lighting, and heating requirements.

In some of Ford's new plants, for example, the use of automated equipment required 40 percent less floor space than nonautomated machinery and equipment producing the same products in the same quantity.

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Thus, automation, although technically possible for many processes, is feasible for only a portion of them, and requires thorough study before it is applied to any process. Where automation can be economically applied, however, the benefits may be fivefold: increased production, lower accident rate, direct labor costs, improved quality in the product, and reduced floor-space requirements.[1]

How widespread is the application of Detroit automation? Actually it is quite limited, mainly because of the small amount of the manufacturing production which is devoted to making large quantities of identical products. Mr. Diebold states, "About 89 to 90 per cent of all American production is in lots of less than 25 individual pieces. It is impossible to build special purpose machines to manufacture these, because the character of the product changes too frequently."[2] This definitely limits the application of Detroit automation.

This does not mean that most of business production will not enjoy participation in automation. The manufacturer who is engaged in producing job lots will be able to buy a versatile machine tool controlled by a punched or magnetic tape, or a punch card. This tape or card will control the machine to produce the desired article automatically. The tapes or cards can be programmed directly from the blueprint. After the required job lot is completed, the card or tape can be filed away for use when a re-order is made.

A variation of this is to have a skilled machine operator machine the first part. His adjustments are recorded on a tape or

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[1]Congressional Subcommittee on Economic Stabilization, <u>Hearings</u>, 1955, pp. 55-56.

[2]<u>Ibid</u>, p. 9.

card and become the master for controlling the machine as the other parts are operated. These flexible tools are relatively new, and therefore there is not much data to judge their role in industry as yet. One such machine used by the Bendix Aviation Corporation has reportedly cut the cost of a master cam from $5000 to less than $500.

If the small business needs a computer, it has the choice of renting one, buying a low cost model, or else renting time on an expensive one. So far their attitude has been to wait and see.

The effect of automation on small business is covered by Mr. Diebold as follows:

> ...automation will very materially help small business. It will make possible through a number of factors, through leasing of capital equipment, which is a practice that is becoming quite common in the automation field, ability to lease decreases capital requirements for business and makes it possible for a smaller business to obtain automation equipment.
>
> Through the introduction of flexible machine tools, it is possible for small shops to compete with some of the larger ones, to have the advantages of automatic operation without the large investments in capital equipment that the large companies undertake. It seems to me that automation is applicable in small industries, and makes for quite effective competition--mobility of small industries is such that there is a very real competitive power in them in competing with large companies. I think that automation provides an additional tool for this.[1]

The position of the small business in relation to automation is covered by the subcommittee's report on the hearings:

> The impact of automation upon the structure of our business society and the relative position of large and small business is a matter of utmost concern. While the subcommittee had this question constantly in mind, the evidence presented is, unfortunately, not conclusive. There can be little doubt but that

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[1]Congressional Subcommittee on Economic Stabilization, Hearings, 1955, p. 37.

large business may find some advantage. The realization of the gains of automation are often dependent upon large initial investment in plant and equipment and result in the mass production and necessity for mass selling of more or less standardized units. On the other hand, there was considerable testimony to the effect (1) that smaller, less expensive models and adaptations of automated machinery will in due course become available, and (2) that relatively small business may be in a position to turn its disadvantages into an element of strength by capitalizing upon its comparative adaptability and flexibility. While big business fights for mass markets, smaller business may capture the business left behind. While big business concentrates on mass assembly, the manufacture of components and parts--even the mass production of components--becomes the opportunity for small new enterprises. There is no doubt that the smaller plants will need to give especial study to product design and standardization problems in order to achieve longer product runs and secure the maximum benefits from automatic machinery.

Small business unquestionably has its problems in the contest for survival. These include the terms of competition, the difficulty of securing sufficient capital, adequate management, and the problems of research and development. The trend toward automatic machinery may result in making these difficulties even greater, but it is far from clear that automation itself is going to add a wholly new and overwhelming set of survival problems of its own.[1]

The effect of automation on business and labor is concisely stated in Finding III of the subcommittee's report:

One highly gratifying thing which appeared throughout the hearings was the evidence that all elements in the American economy accept and welcome progress, change, and increasing productivity. This flexibility of mind and temperament has been a conspicuous characteristic of American industry for generations in well-known contrast to that of many other countries. Not a single witness raised a voice in opposition to automation and advancing technology. This was true of the representatives of organized labor as well as of those who spoke from the side of management. Certainly none of the evidence available before the subcommittee supports a charge that organized labor opposes or resists dynamic progress. Labor, of course, recognizes that automatic machinery lessens the drud-

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[1]U. S. Congress, Subcommittee on Economic Stabilization of the Joint Committee on the Economic Report. Report, Automation and Technological Change, 84th Cong., 1st Sess., 1955, (Washington: U. S. Government Printing Office, 1955), p. 10. (Cited hereafter as Congressional Subcommittee on Economic Stabilization, Report, 1955).

large businesses and find some advantage. The [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

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for the individual worker and contributes greatly to the welfare and standard of living of all.

The fact that representatives of organized labor are watchful lest the material gains of automation become the sole objective, without recognizing the individual hardships that may be caused by job losses and skill displacements, ought not to be turned into a charge that labor, as such, is obstructive to new developments. Whenever one has been in a position to have witnessed firsthand the hardships experienced by the skilled and older worker in any line of endeavor--industrial or professional--suddenly wrenched from his job by the installation of a new machine, or new technology, one can scarcely be unmindful of the inequities which can come about where management and public policy have not given recognition to needs for retraining, relocation, severance pay, and other programs which tend to soften the transition.

Both organized labor and management are apparently aware of and intent upon seeing that these human elements are not disregarded.[1]

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[1]*Ibid*, pp. 4-5.

CHAPTER V

THE EFFECTS OF AUTOMATION ON THE SOCIAL AND ECONOMIC STRUCTURE OF SOCIETY

The biggest problem of automation is the fear of displaced labor. Fortunately, the management of industry and the labor leaders are aware of this problem, and thus far it has not reached the stage of seriousness anticipated by many. In the first place, a certain number of the displaced production workers have been retrained to be the operators or controllers of the automatic machinery. In the second place, generally speaking, the most automated industries have been the expanding ones, which, in spite of automation have been increasing their employment. Consequently, there are jobs available to displaced workers in other production operations. Another source of employment has been the increased maintenance force necessary to service the new equipment. A fourth source of employment has been in the industries for designing, manufacturing and installing the automation equipment, machinery and controls.

> Automation has already produced one new industry in America. There are now more than 1000 companies engaged either wholly or partly in the manufacture of automation equipment. Their aggregate output last year totaled more than $3,500,000-- and the industry is one of the fastest-growing in America.[1]

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[1]John Diebold, "What is Automation?" Collier's, op. cit., p. 42.

A fifth source of employment is an indirect one. Since automation usually produces either a better product and/or a cheaper product, the purchasing power of the dollar has been increased. The purchaser either spends less money or he receives a better quality product, thereby allowing the purchaser to spend the difference on other products, which in turn generates employment.

A sixth source of employment is in new industries made possible by automation. The atomic industry is one that could not exist without remote control of material handling equipment, and remote control of atomic piles for safe operation. Another example is the production of polyethylene, which requires operational precision in reacting time, temperature and pressure. This precision can be obtained only by automation. Without this precision the product, instead of being polyethylene, would turn out to be a useless wax.

Overall labor statistics do not show any decrease of employment during the years automation has had its largest impact. In fact, there has been a shortage of technicians and engineers. This has been the subject of much discussion, particularly in relation to our national defense. Russia, it appears from all statistics, is training superior numbers of personnel in this critical category of labor. This will, in time, give her a technological advantage in superior weapons.

There are some displaced workers, it is true, who have not been re-absorbed by industry. One is a group not capable of being retrained to a job involving automation because of age or ability.

They may remain employed at the same rate of pay, but in a downgraded job. Another group are the workers in an industry which has collapsed in geographical location because of automation in the industry at another location. The latter problem is not new and can be solved by bringing in new industries or having the workers move to areas of labor shortages.

In contrast to these two groups, there is the prospect that the retrained worker will receive higher pay, have a job less dangerous in industrial accidents, and have better working conditions. The high cost of automation equipment requires business to use this equipment fully in order to recover the cost. This, in turn, will automatically secure for the worker a guaranteed annual wage in automated industries. The net result is an increase in the dignity of the worker. Instead of being paced by the machine, he will be pacing the machine.

Many forecasts have been made as to future benefits of automation. Many forecasters emphasized that eventually shorter working hours would appear. This would allow more leisure for recreation, travel, reading, education and suburbanization. But as material needs become satisfied by shorter hours of labor, will we be able to develop a culture that will give meaning to our lives?

The prospect of shorter hours of labor does not seem imminent. The present forecast, based on the huge postwar crop of babies, seems to indicate that with a labor force that will increase only 11% by 1960, we will need 40% more consumer goods.

The need for more technicians and engineers for the national defense has been commented on. But the designing, manufacturing,

installation, and operation of automation machinery will also require more technical competence in the worker. Consequently, the future worker will need more education and training.

Automation is producing new products, better products, and cheaper products. This will raise the standard of living of this country. A lower percentage of the family income will be spent on food, clothing, and housing, allowing more money for other necessities, including medical expenses. We can expect a longer life expectancy.

Dr. Cledo Brunetti, Director of Engineering, Research and Development, General Mills, Inc., sums up the advances made in the United States due to technological progress:

> Today, because of mechanization, the average family enjoys a standard of living of over 30 percent higher than in 1940. Home ownership is steadily increasing, with nearly 30 million families now owning their own homes, compared with half this number in 1940. Nearly 40 million families, or three-quarters of the United States total, own their own automobiles, and over 10 percent are 2-car families. I am quoting public figures here.
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> Yet we have untold numbers of new products which will find their way into the homes in the years to come. For while 98 percent of the homes are supplied with radio and electricity, only 68 percent have telephones, 56 percent have vacuum cleaners, 5 percent have clothes dryers, and only 3 percent have air conditioners
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> To glean another view of what mechanization has done for us, let us take a look at the past and compare it with our present situation. Our present labor force is 65 million people. Suppose we were to trace back to what it might have been without any mechanization. Our country would not have turned out to be the land of opportunity and we would find the United States with a population closer to 40 million than 165 million. Our economy would be one of farming, fishing, hunting, and hand manufacture of furniture and home necessities. If you include the principal homeworker, who would certainly be working, we estimated there would be about 14 million jobs, leading to the fact that we owe

some 51 million of our present jobs to mechanization of one form or another.[1]

Walter P. Reuther, President of the Congress of Industrial Organizations, in a few words has summed up the challenge of automation: "If we accept the challenge of the new technology, if we use foresight and act wisely and vigorously, we can help to usher in an age of abundance and freedom, the like of which the world has never known." [2]

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[1]Congressional Subcommittee on Economic Stabilization, Hearings, 1955, p. 370.

[2]Ibid, p. 114.

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